EVALUATION OF LINGUAL FRACTURE PATTERN OF THE MANDIBLE AFTER BILATERAL SAGITTAL SPLIT OSTEOTOMY WITH AND WITHOUT INFERIOR BORDER OSTEOTOMY

Dissertation submitted to

THE TAMILNADU Dr. MGR MEDICAL UNIVERSITY

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BRANCH III

ORAL AND MAXILLOFACIAL SURGERY

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CHENNAI

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation titled **"EVALUATION OF LINGUAL FRACTURE PATTERN OF THE MANDIBLE AFTER BILATERAL SAGITTAL SPLIT OSTEOTOMY WITH AND WITHOUT INFERIOR BORDER OSTEOTOMY"** is a bonafide record and genuine research work done by me under the guidance of **Dr. D. SANKAR, M.D.S., FIBOMS., FIBCSOMS,** Professor, Department of Oral & Maxillofacial Surgery, Ragas Dental College and Hospital, Chennai.

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ABSTRACT

PURPOSE: The purpose of the study was toevaluate the pattern of lingual split linewhen performing a bilateral sagittal split osteotomy (BSSRO) with different osteotomy methods.

MATERIALS AND METHOD:

A total of 15 dry cadaveric mandible was taken for the study.The classical Obwegeser and Dalpont technique in left side and additional inferior border osteotomy cut in right side of BSSRO was compared based on modified lingual split scale.The maximum torque force that was needed to split the mandible was recorded and the fracture pattern was observed. Similar osteotomies were performed in 15 fresh goat mandible (sacrificed for food) which acted as control group.

RESULTS:

The cadaveric dry mandible recorded an average torque of 12.6 $\pm$2.4 Nm (SD: 0.32) with a maximum of 16.0 Nm and a minimum of 8.0 Nm in left side . 80% of the mandible were Type I fracture pattern and 20% had Type III fracture pattern.In contrast with the modified BSSRO technique with an additional inferior border osteotomyrequired amaximal torque of 12.0 N and a minimal torque of 5.0 with an average required torque of 8.7 $\pm$ 2.1 N on the right side of the mandible. 93% of the cases split by Type II fracture pattern in the modified BSSRO technique.

In Goat MandibleObwegeser Dal Pont recorded an average torque of 16.5 N $\pm$ 2.8N (Range 21 N to 12 N) and modified BSSRO technique in right side recorded an average torque of 9.2 N $\pm$ 2.9 N (Range 6N to 18 N) .In

Obwegeser Dal Ponttechnique80%of the mandible split by type I fracture pattern and 100% the hemi-mandibles split by Type II fracture pattern.

CONCLUSION:

The new technique resulted in predictable splitting of the mandible along the lower border away from the mandibular canal (Type II) and also decreased the force needed to complete the osteotomy by 31 percent when compared to the Obwegeser and Dal-pontBSSRO technique.

KEYWORDS: Bilateral Sagittal Split Osteotomy, Cadaveric Mandible , Modified Lingual Split Scale, Inferior Alveolar Nerve.

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Introduction

INTRODUCTION

The evolution of the specialty of oral and maxillofacial surgery has paralleled the evolution of medical science in general. In reflecting on this process, an event that may have marked the beginning of this evolution, for oral surgery, was the introduction of the sagittal split osteotomy. An osteotomy of the mandible is one of the commonest surgical procedures used in orthognathic surgery. At the beginning of the last century extraoral approaches were used to achieve this goal (Blair:1914; Kostecka:1931, Kazanjian:1951) which frequently resulted in visible scarring, pseudarthrosis, lip numbness and even facial nerve palsy.

A milestone was set by Trauner and Obwegeser[47] (1955, 1957), who introduced the technique of the bilateral sagittal split osteotomy (BSSRO), then conducted via an intraoral approach. This new technique led to a significant reduction in all complications. Furthermore, aesthetic results improved, as the proximal mandibular segment remained in its original position. Since its introduction many modifications of the original technique have been described to decrease the risk of bad splits, to avoid bony non-union and to prevent trauma to the alveolar nerve. A procedure evolved that could be accomplished intraorally, without facial scars, and did not require the inconvenience of prolonged intermaxillary fixation.

The following review of the literature is an attempt to isolate those modifications which marked significant advances in this technique.

Schuchardt Modification [51]

Schuchardt modified the previously highly problematic horizontal mandibular Osteotomy by introducing a technique in which a horizontal cut was made above the lingula just through the medial cortical plate and extended to the posterior border of the ramus. This cut was then connected to a horizontal cortical cut in the lateral cortical plate 1 cm below. The modification could be accomplished intraorally and afforded a larger medullary approximation. The procedure resulted in a minor decrease in complications but was far from being an acceptable approach.

Obwegeser Modification [51]

Obwegeser expanded on Schuchardt's technique by increasing the separation between the horizontal cuts to 25 mm. The horizontal cuts were connected with a cut along the medial aspect of the lateral oblique ridge. Neither Obwegeser nor Schuchardt advocated stripping of the masseter or medial pterygoid muscles. It is likely that, to get the necessary exposure to make these cuts, there was rather wide periosteal stripping. Obwegeser advocated incising the 'periosteal band'. The increase in the distance between the horizontal cuts greatly increased the amount of approximated bone and also the stability of the procedure.

Rajchel[51] in (1986) his article on the location of the mandibular canal and its relationship to the sagittal ramus osteotomy was the first to report specifically on the medio lateral position of the mandibular nerve. This research suggested the extension of the sagittal osteotomy cut into the area of the first molar for the following reasons: (1) the buccal cortical plate is thicker, (2) the total mandibular body width is thicker, and (3) the distance between the inner aspect of the buccal cortical plate and the mandibular canal is consistently greater in that location. They went on to describe this area as a 'bony prominence, an extension of the lateral oblique line'. They reported that, in their experience, the area just distal to the third molar is the area where the neurovascular bundle most often is in direct contact with the buccal cortical plate and that occasionally the neurovascular bundle and canal appears to be within the buccal cortical plate, so that area would be the least favorable for cuts to be made.

Dalpont Modification[51]

Obwegeser's procedure was the real beginning of the sagittal split osteotomy. This received little attention among US surgeons until he visited USA and spoke to groups of oral surgeons in 1966. Dal Pont gave a modification such that he advanced the lower horizontal cut to the buccal cortex of the mandibular body as a vertical cut between the first and second molars that he called the 'oblique retromolar osteotomy'. In this technique the lingual horizontal cut was stopped just past the lingula. A vertical cortical cut was made in the area between the first and second molars, just as it was in his first method. These two cuts were connected by a cut passing from the lateral oblique ridge through to the mylohyoid groove on the lingual. This cut left both the medial pterygoid and the masseter muscles attached to the proximal fragment.

Hunsuck Modification

Hunsuck[20] (1968) found that it wasn't necessary to make an actual cut through to the lingual as Dal Pont had done in his connecting cut. The Dal Pont lingual split would occur naturally as chisels were used to split the mandible. Hunsuck's superior cut was the same as the cut that Dal Pont used in his oblique retromolar osteotomy. Hunsuck's anterior vertical cut was made in the area that he referred to as the 'union of the ascending ramus and the body of the mandible in the tooth stabilization. This technique, like Dal Pont's, required only minimal muscle and periosteal stripping. With Hunsuck's modifications of the basic Obwegeser technique, all of the major components of the contemporary design for the sagittal split technique were in place. The subsequent modifications have generally, focused on attempts to manage or minimize intra surgical or post-surgical problems.

In Europe, where this orthognathic revolution originated, the next major modification was occurring. Spiessl and his associates were experimenting with rigid internal screw fixation. In 1976 Spiessl et al. published their book 'New Concepts in Maxillofacial Bone Surgery"' in which they introduced rigid internal fixation in the form of interfragmentary bone screws. This book also encouraged the use of micro saws as a method of making precise bone cuts while preserving bone. Spiessl advocated a modification in which the lateral oblique ridge was removed to facilitate the use of smaller than traditional chisels to make the split closely follow the buccal cortical wall. Following the cortical plate in that manner decreased injuries to the mandibular nerve. He also included some preliminary studies on the variation of the location of the mandibular nerve relative to the buccal and inferior mandibular cortexes. His research showed that the screws added to the stability of the fragments and decreased healing time because of fragment compression.

Besides the introduction of new operative techniques to split the mandible, new instruments were developed to refine existing techniques and to make it more atraumatic. Markiewicz introduced a new retractor to improve the vertical osteotomy in the Obwegeser Dal Pont operation (Markiewicz and Margarone, 2008). A refined technique for a less traumatic operation by endoscopy was presented by Mommaerts (2009). Nevertheless, the risk of unexpected fractures is a major disadvantage of the BSSRO (Kriwalsky[27] et al., 2008), known as "bad splits". Previous reports have cited an incidence of bad splits of up to 5%, in spite of improved preoperative diagnostics (Ylikontiola[28] et al., 2002; Tsuji et al., 2005)

When performing a BSSRO, with Dalpont and Hunsuck modification there is no visual control of the lingual split pattern that occurs during the split procedure. Postoperative nerve damage in a BSSRO, might be a result of the fact that the exact split pattern is unknown during the surgery.

Furthermore, Plooij et al[22] emphasized that the possible influence of the lingual fracture line (and its absence of control and visualization) could be a possible factor in damaging the IAN and influencing the fracture line due to the placement of the (medial) bone cuts. Plooij[22] et al investigated the lingual fracture line using 3D-CT after BSSRO performed by the Hunsuck modification and reported that only 51% of the fracture lines ran according to Hunsuck's description, whereas 33% ran through the mandibular canal. It seems that the lingual fracture lines after BSSRO were influenced by the positions of the end, of the medial and lateral bone cuts.

In 1990 Wolford[50] introduced the concept of the additional inferior border split along with 0bwegesser Dalpont technique. A specially designed saw was used to cut the inferior border from the inferior side. This modification was deemed necessary because of their observation that, in the conventional split, the split usually occurred in the lingual cortical plate. The high lingual side split made the placement of the inferior border screw difficult because of the lack of bone to screw below the neurovascular bundle or canal. The other disadvantage of the split on the lingual side was that the nerve frequently went with the proximal fragment and was thus more difficult to visualize and to separate.

In this modified Wolford technique, the inferior border of mandible is weekend by an osteotomy, thus creating a new line of minor resistance. In this way it was hoped to reduce the osteotomy depth and additionally reduce the torque necessary for the splitting process. This should make the splitting man oeuvre more controllable and lead to fewer complications in repositioning the mandible. It is interesting to evaluate whether the characteristics of the fracture line are influenced or can be controlled, by adaptation of the length or direction of the medial and buccal bone cuts or whether the fracture line simply seeks the path at least resistance.

Aims & Objectives

AIMS AND OBJECTIVES

The purpose of the study was to evaluate the pattern of lingual split line when performing a bilateral sagittal split osteotomy (BSSRO) with Obwegeser- Dal Pont technique and Modified BSSO with additional inferior border osteotomy cut.

Review of Literature

REVIEW OF LITERATURE

Robert Bruce Macintosh et al (1981)[29],conducted a review study on Experience with the Sagittal Osteotomy of the Mandibular Ramus A 13-Year Review. This report surveys the experience in 236 patients operated on by the author, of whom 155 provided records complete enough to provide information on all the elements of postoperative evaluation. Patients were evaluated at a minimum of 2 years after surgery. The patients had an average age of 23 years, and were predominantly female in a ratio of more than 4:1. No intraoperative or postoperative physiologically threatening problems as elsewhere described in the literature, such as profound blood loss, airway obstruction, or gross loss of bone substance, were encountered. An immediate postoperative paraesthesia incidence of almost 85 % was observed, which diminished to 9 % 1year postoperatively. The prolonged paraesthesias were most common in patients over 40 years of age; similarly, healing was prolonged in patients over 40, prompting the author's recommendation that 8 weeks intermaxillary fixation rather than 6 be employed in these patients. The overall relapse rate was approximately 30 %; this was clinically significant in approximately12 % of patients, and required reoperation in 4 patients. Relapse was most marked in apertognathic patients, demonstrating, in the author's opinion, that the sagittal ramus osteotomy should not be used, in general, in open-bite cases.

A. Stott Carletonet al (1986)[11], conducted a study on Prevention of the Misdirected Sagittal Split concluded the original medial osteotomy may be extended to the posterior border of the ramus, or, alternatively, a more inferiorly placed osteotomy can be made. Both of these methods result in added tissue trauma and require additional time. The purpose of this paper is to present an explanation for the occurrence of the misdirected sagittal split and to suggest an approach for its prevention.

Larry Wolford et al in (1987)[49], conducted a surgical technique on Modification of the mandibular ramus sagittal split osteotomy, the soft tissue incision is made along the external oblique ridge, beginning about 1 cm above the second molar. The anterior border of the ramus, the internal oblique ridge, and the medial aspect of the mandible are exposed. Minimal temporalis muscle is reflected off the coronoid to decrease direct muscle trauma. The tissuereflection from the medial aspect of the mandible above the lingula is accomplished with a 60" angled freer elevator to provide access for the medial cut. The medial osteotomy is directed perpendicular to the ascending ramus at the level of the superior aspect of the lingula. The cut is extended at least 3 to 6 mm posterior to the lingula and is carried to the depth of the medial surface of the buccal cortex. A cut is made down the ascending ramus adjacent and parallel to the buccal cortex to a point 5 to 10 mm posterior to the second molar. The soft tissue dissection is completed under the inferior border of the mandible at the anterior aspect of the genial notch, so as to maintain a maximum amount of masseter muscle and periosteum attachment to the proximal segment. The lateral horizontal osteotomy is performed in the length and angulation determined on the ST0. With a narrow (701) fissure bur, the horizontal cut is made through the lateral cortical plate perpendicular to the long axis of the teeth. This cut creates a horizontal bone ledge superior to the proximal segment, which will control the postoperative position of the proximal segment. The anterior aspect of the ascending ramus osteotomy is connected with the posterior aspect of the horizontal cut. A vertical cut is made with a 703-fissure bur through the buccal cortex, extending from the anterior aspect of the horizontal osteotomy through the mandibular inferior border to complete the bone cuts. It is important to complete this osteotomy through the inferior border of the mandible, including 2 to 3 mm of the lingual cortex, as failure to complete this cut may lead to subsequent fracture of the buccal cortex. The distal area of the first molar is a safe area in which to perform the vertical buccal osteotomy since the inferioralveolar neurovascular bundle is located toward the lingual cortical plate.

Larry Wolford et al (1990)[50], conducted a study on The Mandibular Inferior Border Split: A Modification in the Sagittal Split Osteotomy, the modified technique involves an inferior borderosteotomy as part of the preliminary bone cuts made before sagittally splitting the mandible. Specially designed blades (Techmedica, Camarillo, CA) have been developed to allow cutting of the inferior border of the mandible with the reciprocating saw. The blades are offset to the left or right side to provide access for cutting on either side of the mandible. Once the medial, ascending ramus and buccal vertical osteotomies are completed, the blade is used. It is best to begin the cut anteriorly adjacent to the vertical buccal osteotomy. The blade should be oriented so that the cutting edge is parallel to the inferior border of the mandible and it bisects the buccal-lingual thickness of the cortex. The saw blade is 5 mm at its maximum height, which will allow it to penetrate through most inferior border cortices and not damage the neurovascular bundle. The reciprocating action of the saw blade is started at half speed and it is sunk to the appropriate depth before increasing the speed. The blade is then directed posteriorly toward the distal aspect of the antegonial notch area. It is then directed medially so that it will come out through the lingual cortex anterior to the angle of the mandible. The operator should be very conscious when making the inferior border cut to realize the shape and contour of the inferior border as well as the shape of the blade. The reciprocating saw hand piece and blade should be oriented so that the blade will cut maximally up into the bone. This means that once the saw blade has been engaged, the handpiece is rotated superiorly so that the triangular blade can cut most effectively. There is a protective, rounded shaft at the inferior aspect of the blade that will prevent the blade from going further up into the osteotomy area. If there is inadequate vertical cutting of the inferior border, then there is still the risk that a buccal cortical fracture or the standard medial fracture above the inferior border might occur. Once the inferior border cut is finished, the sagittal split is completed by prying the segments apart; no malleting is necessary. The less force used to separate the segments, the less intraoperative trauma to the temporomandibular joints.

Brian R. Smith et al (1991)[45], conducted a study on Mandibular Ramus Anatomy as It Relates to the Medial Osteotomy of the Sagittal Split Ramus Osteotomy concluded that where fusion of the buccal and lingual cortical plates occurs in the upper mandibular ramus, as it is thought that placement of the horizontal medial osteotomy above the point of fusion (without any intervening medullary bone) may lead to unfavorable fracture during splitting. The location of the medial horizontal osteotomy should be at or just above the tip of the lingula. A higher level of cut may be associated with an increased difficulty in splitting or incidence of unfavorable fracture.

M. Y. Mommaerts et al (1992)[35], conducted a two similar "bad splits" and how they were treated. Two high fractures of the proximal segments during separate sagittal split osteotomies were treated by a modification of the "Obwegeser II" technique and screw osteosynthesis. Careful wedging of the large spreading osteotome in a more superior position while splitting up to the posterior border will probably prevent such complications.

W. M. Wyatt et al (1997)[51], conducted a Sagittal ramus split osteotomy: literature review and suggested modification of technique, the basic design of the sagittal ramus split surgical procedure evolved very quickly. The elimination of the problems encountered has taken longer. Some of these problems are yet to be satisfactorily resolved. This paper presents a review of the literature which appears to define the evolution of this procedure. With this information in mind, a minor modification in the traditional mandibular sagittal ramus technique is presented.

S. Akhtar et al (1999)[2], stated that in his experience that removal of third molars at least 6 months before an SSO is associated with a lower incidence of unfavorable splits than the literature would suggest. This appears to be an effective technique even in those patients who have unfavorable deformities with anatomically small rami (high angle mandibular deficiencies). Although we agree that overexuberant bone removal may be one of the causes of some unfavorable splits, it is our belief that lack of attention at the crucial time when the split is being performed is probably the most critical factor. In addition, anatomic or technical differences- the ratio of the height of the third molar to the mandibular body, for example, or the technique used in the molar removal (such as the lingual split method) may contribute to this complication.

Michael Miloro et al (2000)[30], conducted a study on Low-level laser effect on neurosensory recovery after sagittal ramus osteotomy. Consecutive patients undergoing bilateral sagittal split osteotomy procedures were enrolled in this prospective study. A complete preoperative clinical neurosensory test, consisting of brush stroke directional discrimination, 2-point discrimination, contact detection, pin prick nociception, and thermal discrimination, was performed on each patient; and a subjective assessment of neurosensory function was made by using a visual analog scale (VAS). The protocol for LLL treatments consisted of real LLL (4 x 6 J per treatment) along the distribution of the inferior alveolar nerve at 4 sites, for a total of 7 treatments, delivered immediately before surgery; at 6 and 24 hours after surgery; and on postoperative days 2, 3, 4, and 7. The clinical neurosensory test and VAS were completed just before each of the treatment sessions and on days 14 and 28, by one examiner stroke directional discrimination approached normal values by 14 days, whereas 2-point discrimination and contact detection showed significant improvement at 14 days and returned to near-normal values by 2 months. The results of thermal discrimination and pin prick nociception revealed few neurosensory deficits; however, those patients who were affected showed a slower recovery trend and remained neurosensory-deficient for up to 2 months. The VAS analysis revealed a rapidly progressive improvement in subjective assessment, showing a 50% deficit at 2 days only a 15% subjective deficit at 2 months. This study demonstrates that neurosensory recovery after bilateral sagittal split osteotomy procedures can be significantly improved, both in terms of time course and magnitude of return of function, with the adjunctive use of LLL therapy.

Leena Ylikontiola et al (2002)[28], conducted a study on Comparison of three radiographic methods used to locate the mandibular canal in the buccolingual direction Before bilateral sagittal split osteotomy and concluded that the buccolingual location of the mandibular canal is visualized better with CT than with Scanora orpanoramic radiographs.

Marcus Stephan Kriwalsky et al (2007)[27], has studied the clinical notes of 110 Consecutive patients who had had a total of 220 SSOs using the Obwegeser/Dal Pont technique were evaluated and divided into three groups: 1 missing third molar (n = 168); 2 retained or impacted third molar that was removed during the SSO (n = 23); and 3 third molar left in place during SSO (n = 29).There were a total of 12 (6%) bad splits. 9 (5%) in group 1, two (9%) in group 2, and one (3%) in group 3. There were no significant differences between groups 1–3, in particular the surgeon’s qualification had no influence on the incidence. Older patients seemed more at risk of a bad split than younger ones.

Shimon Rochkind et al (2007)[42], conducted a study on Laser Phototherapy (780 nm), a New Modality in Treatment of Long-Term Incomplete Peripheral Nerve Injury,the laser-irradiated and placebo groups were in clinically similar conditions at baseline. The analysis of motor function during the 6-monthfollow-up period compared to baseline showed statistically significant improvement in the laser treated group compared to the placebo group. No statistically significant difference was found in sensory function. Electrophysiological analysis also showed statistically significant improvement in recruitment of voluntary muscle activity in the laser-irradiated group, compared to the placebo group. Concluded that in patients with long-term peripheral nerve injury noninvasive 780-nm laser phototherapy can progressively improve nerve function, which leads to significant functional recovery.

R. B. Veras et al (2008)[39], compared the Functional and radiographic long-term results after bad split in orthognathic surgery concluded 110 cases of mandibular hypoplasia treated with BSSO, 7 cases of bad sagittal splits (Group A) were selected, clinically examined and matched to 7 cases where no bad split occurred (Group B). The Research Diagnostic Criteria for Temporo Mandibular Disorders (RDC/TMD), condylar morphology scale (CMS) and ramus height measurements using orthopantomograms were carried out in the follow-up period to observe the clinical and functional status and condylar resorption or remodeling. The mean follow-up time was 28.6 months. The RDC/TMD examination did not show a higher incidence of temporomandibular dysfunction, including pain or clicking in the bad split group. Patients without a bad split showed statistically significant ($p < 0.05$)

better mouth opening. The CMS measurements were comparable in both groups. When compared with regular splits, bad splits, if treated in an appropriate manner, have a good chance of functional success, although, some mandibular movements can be compromised.

J. M. Plooij et al (2009)[22], conducted a study on 3D evaluation of the lingual fracture line after Bilateral sagittal split osteotomy of the mandible the split pattern was influenced by the length of the medial Osteotomy. 3D imaging is a useful tool for analyzing the surgical outcome of a BSSRO and has the potential to provide substantial data on the position of the proximal segments as a result of the lingual fracture line.

Bart Falter et al (2010)[15], conducted a study on Occurrence of bad splits during sagittal split osteotomy concluded that A bad split occurred in 14 SSO sites (14 of 2005 sites). No bilateral bad splits occurred. There was no notable decrease of bad splits over the 20 years. All bad splits were resolved perioperatively by plate-osteosynthesis without the additional need of intermaxillary fixation. All patients with a bad split had a good and functional occlusion 6months postoperatively. No infections occurred at the site of the bad splits. No bad splits occurred in patients younger than 20 years. No particular type of dental-facial deformity, or skeletal class according to the Angle's classification could be correlated with cases of bad splits as a predisposing risk factor.

Roland Bockmannet al (2011)[7], conducted a study on Pilot study of modification of the bilateral sagittal split osteotomy (BSSRO) in pig mandibles. For this purpose, a test system was designed and 100 pig mandibles were split to assess the test's reliability, to compare the torque necessary to split the mandible in both techniques and to record the fracture lines. The splitting technique was standardized, avoiding any contact with the inferior alveolar nerve. By using the new technique, we demonstrated a decrease in the torque force required to split the mandible of 29.7% (t(69)¼_12.68; $p < 0.05$, paired t-test) compared to the Obwegeser Dal Pont technique. The fracture lines were close to ideal.

P. Schoen et al (2011)[43], conducted a study on Modification of the bilateral sagittal split osteotomy (BSSRO)in a study using pig mandibles, A modification of the Obwegeser–Dal Pont operation technique was studied by splitting 100 pig mandibles ex vivo. An additional osteotomy
at the caudal border of the mandible was used to facilitate the sagittal split by means of a locus of minor resistance. The chisel was inserted distal to the second molar and far away from the IAN.The mandible was split by torque. The modified technique reduced the required torque to split the mandible about 30% compared with the original technique (paired t-test, t(69) = _12.89; $p < 0.05$). 75% of all mandibles split by the modified technique were classified as bad splits compared with 100% using the original technique using the same protocol without the additional
osteotomy.

Toshitaka Muto et al (2012)[36], Evaluated the Mandibular Ramus Fracture Line After Sagittal Split Ramus Osteotomy Using 3-Dimensional Computed Tomography, concluded a desirable splitting pattern occurred when a short lingual cut just above the lingula and a lateral bone cut of the mandibular angle were made, extending to the inside through the inferior border of the mandible. These observations also proved that the split patterns of the mandibular ramus could be controlled by the position of the lateral bone cut end.

Gertjan Mensink et al (2013)[34], did a retrospective study on Bad split during bilateral sagittal split osteotomy of the mandible with separators: a retrospective study of 427 patients and concluded the study group comprised 427 consecutive patients among whom the incidence of bad splits was2.0%/site, which is well within the reported range. The only predictive factor for a bad split was the removal of third molars at the same time as BSSRO. There was no significant association between bad splits and age, sex, class of occlusion, or the experience of the surgeon. We think that doing a BSSO with splitters and separators instead of chisels does not increase the risk of a bad split, and is therefore safe with predictable results.

G. Mensink et al (2013)[32], conducted a study on Bilateral sagittal split osteotomy in cadaveric pig mandibles: evaluation of the lingual fracture line based on the use of splitters and separators and concluded that almost all lingual fracture lines ended in the mandibular foramen, most likely due to the placement of the medial cut in the concavity of the mandibular foramen. The mandibular foramen and canal could function as the path of least resistance in which the splitting pattern is seen. We conclude that a consistent splitting pattern was achieved without increasing the incidence of possible sequelae.

Bilal Al-Nawas et al (2013)[10], conducted a retrospective study on Influence of osteotomy procedure and surgical experience on early complications after orthognathic surgery in the mandible, patients who underwent a mandibular osteotomy (Obwegeser Dal Pont (ODP) and Hunsuck Epker (HE)) were included. Incidence of “bad splits”, “bleeding episodes”, “delayed wound healing”, “failed osteosynthesis” and “nerve lesions” at 2 months postoperatively were recorded. Surgical experience was classified as: beginner (<10), intermediate (10 e40) and expert (>40). Complications were correlated to the surgical approach and the experience level of the surgeon.

And the author concluded that the Hunsuck and Epker osteotomy showed a more reliable fracture mechanism with less relevant bleeding episodes. Differences between the surgeons of varying training status were marginal with exception of a higher rate of osteosynthesis failure and temporary hypoesthesia in the experienced group

H Ghiasi et al (2013)[18], **conducted a** questionnaire study on Incidence of long-lasting neurosensory disturbances after bilateral sagittal split osteotomy, concluded that half of the operated subjects had long-lasting neurosensory disturbance. However, the majority of the patients (89%) were satisfied with the result of the operation despite sensory disturbances of some degree. It appears that neurosensory disturbance is not the main determining factor of patient satisfaction and seems outbalanced by pre-operative information and results of function and aesthetics.

Jop P. Verweij et al (2014)[24], the presence of mandibular third molars during surgery increases the possibility of bad split but does not affect the risk of other complications. therefore, third molars can be removed concomitantly with BSSO using sagittal splitters and separators.

Mohammadali Aarabiet al (2014)[1], conducted a retrospective study Relationship Between Mandibular Anatomy and the Occurrence of a Bad Split Upon Sagittal Split Osteotomy. Forty-eight patients (96 SSO sites) were studied. The buccolingual thickness of the retromandibular area (BLR), the buccolingual thickness of the ramus at the level of the lingula (BLTR), the height of the mandible from the alveolar crest to the inferior border of the mandible, (ACIB), the distance between the sigmoid notch and the inferior border of the mandible (SIBM), and the anteroposterior width of the ramus (APWR) were measured. The independent t test was applied to compare anatomic measurements between the group with and the group without bad splits. The receiver operating characteristic (ROC) test was used to find a cutoff point in anatomic size for various parts of the mandible related to the occurrence of bad splits. This study showed that certain mandibular anatomic differences can increase the risk of a bad split during SSO surgery.

J.O. Agbaje et al (2014)[23], conducted a Systematic review of the incidence of inferior alveolar nerve injury in bilateral sagittal split osteotomy and the assessment of neurosensory disturbances conclude that the observed wide variation in the reported incidence of IAN injury is due to a lack of standardized assessment procedures and reporting. Thus, an international consensus meeting on this subject is needed in order to establish a standard-of-care method.

Marina Kuhlefelt et al (2014)[31], conducted a study on Nerve Manipulation During Bilateral Sagittal Split Osteotomy Increases Neurosensory Disturbance and Decreases Patient Satisfaction, Although NSD was frequent 1 year after BSSRO, most patients were satisfied with the treatment. However, a risk for severe NSD or neuropathic pain does exist in a small group of patients. Thesepatients should be identified at an early stage so that proper medical and supportive treatment can be initiated. If necessary, a multidisciplinary pain center should be consulted. The importance of accurate patient information preoperatively cannot be overstated.

Jop P. Verweijet al (2015)[26], studied Angled Osteotomy Design Aimed to Influence the Lingual Fracture Line in Bilateral Sagittal Split Osteotomy: A Human Cadaveric Study that the angled osteotomy design, The traditional osteotomy design in the bilateral sagittal split osteotomy includes a horizontal lingual bone cut, a connecting sagittal bone cut, and a vertical buccal bone cut perpendicular to the inferior mandibular cortex. The buccal bone cut extends as an inferior border cut into the lingual cortex. This study investigated a modified osteotomy design including an angled oblique buccal bone cut that extended as a posteriorly aimed inferior border cut near the masseteric tuberosity promotes a more posterior lingual fracture originating from the inferior border cut and a trend was apparent that this also might decrease the incidence of bad splits and IAN entrapment.

Roland Bockmann et al (2014)[9], conducted a study on the Modifications of the Sagittal Ramus Split Osteotomy: A Literature Review, the basic design of the sagittal ramus split surgical Procedure evolved very quickly. The original operation technique by Obwegeser was shortly after improved by Dal Pont's modification. The second major improvement of the basic technique was added by Hunsuck in 1967. Since then, the technical and biological procedure has been well defined. Resolution of the problems many surgeons encountered has, however, taken longer. Some of these problems, such as the unfavorable split or the damage of the inferior alveolar nerve, have not been satisfactorily resolved. Further modifications, with or without the application of new instruments, have been introduced by Epker and Wolford, whose modification was recently elaborated by Bockmann. The addition of a fourth osteotomy at the inferior mandibular border in an in vitro experiment led to a significant reduction of the torque forces required for the mandibular split. The literature was reviewed, and the last modifications of the successful traditional splitting procedure are presented narrowly. It indicates the better the split is preformatted by osteotomies, the less torque force is needed while splitting, giving more control, a better predictability of the lingual fracture and maybe less neurosensory disturbances of the inferior alveolar nerve.

Roland Bockmann et al (2015)[8], conducted a study in vitro comparison of the sagittal split osteotomy with and without inferior border osteotomy concluded that the average torque associated with the original technique was 1.38 Nm (SD:0.60), with a fracture line along the mandibular canal. The average torque required to split the hemi-mandible with the modified technique was with 1.02 Nm (SD: 0.50), a significant ($p<0.001$) difference, with a fracture line parallel to the posterior ramus of the mandible. The fracture pattern depended significantly on the used technique($p<0.001$), but not between the torque force and the fracture pattern. By adding an osteotomy of the inferior mandibular border to the sagittal split osteotomy, less torque was needed to split the mandible. The fracture line was more predictable, even if all of the surgical manipulations were performed at a safe distance from the inferior alveolar nerve.

Min Hou et al (2014)[19], conducted a study on Evaluation of the mandibular split patterns in sagittal split ramus osteotome,130 patients with different maxillofacial deformities (62 males and 68 females) with a mean age of 23 years underwent a BSSRO. Two types of split patterns Mandibular ramus were observed in BSSRO split at the lingual side nearby the mylohyoid sulcus, which occurred in 75.38% of the patients, and split at the posterior border region of the mandibular ramus, which occurred in 24.62% of the patients. No fracture lines were observed through the mandibular canal. The thickness of the lingual cortical bone between the mandibular canal and the posterior border of the ramus was significantly associated with split patterns ($P<0.05$). The thickness of the cortical bone in the posterior border of the ramus, the degree of the mandibular angle and the shapes of the mandibular ramus in the axial plane were also found to influence these split patterns. There was no significant association between split patterns, age and gender. The split patterns of the mandibular ramus in BSSRO were influenced by some anatomical features of the mandibular ramus. Therefore, examining the anatomy of the mandible with CBCT before the surgery may play an important role in predicting the split patterns of the mandibular ramus in BSSRO.

Alberto Fuhrer-Valdivia et al (2014)[3], conducted a randomized study on low-level laser effect in patients with neurosensory impairment of mandibular nerve after sagittal split ramus osteotomy. with an experimental group (n=17) which received laser light and a control group (n=14), placebo. All participants received laser applications, divided after surgery in days 1, 2, 3, 5, 10, 14, 21 and 28. Neurosensory impairment was evaluated clinically with 5 tests; visual analogue scale (VAS) for pain and sensitivity, directional and 2-point discrimination, thermal discrimination, each one of them performed before and after surgery on day 1, and 1, 2 and 6 months. Participants and results evaluator were blinded to intervention. Results demonstrate clinical improvement in time, as well as in magnitude of neurosensory return for laser group; VAS for sensitivity reached 5 (normal), 10 participants recovered initial values for 2-point discrimination (62,5%) and 87,5% recovered directional discrimination at 6 months after surgery. General VAS for sensitivity showed 68,75% for laser group, compared with placebo 21,43% (p-value = (0.0095). Left side sensitivity (VAS) showed 3.25 and 4 medians for placebo and laser at 2 months, and concluded that Low-level laser therapy was beneficial for this group of patients on recovery of neurosensory impairment of mandibular nerve, compared to a placebo.

Andrew Kataba et al (2014)[5], conducted a study on Clinical Anatomy of the Head Region of Gwembe Valley Dwarf Goat in Zambia, in this study, a total of 30 skulls of the Gwembe Valley Dwarf (GVD) goat were used. Clinical anatomical measurements for 12 parts of the skull were made.

Additionally, the data obtained have been compared with those carried out on West African Dwarf (WAD) and Markhoz goats. The distance from the facial tuberosity to the infraorbital canal and from the latter to the lateral alveolar root were 2.06±0.14 cm and1.13±0.11 cm, respectively. The distance from the lateral alveolar root to the mental foramen was 1.58±0.19 cm and from the mental foramen to the caudal mandibular border was 9.26±0.49 cm. In addition, the length and the maximum height of mandibles were 11.24±0.52 cm and 6.64±0.44 cm, respectively. The distance from the caudal border of mandible to below the mandibular foramen was 1.21±0.08 cm, while distance from the mandibular foramen to the base of the mandible, the caudal border of the mandible to the level of the mandibular foramen and mandibular foramen to the mandibular angle were 2.35±0.26 cm, 1.10±0.07 cm and 2.18±0.19 cm, respectively. According to our findings, the clinical anatomy values of the head region in this breed were more comparable to WAD and Markhoz goat. These results are of clinical importance and will aid in regional nerve blocks of the infraorbital, mental and mandibular nerves useful during head injuries, surgical operations involving the lips and dental extraction in this breed.

Sunanda Roychoudhury et al (2015)[46], conducted a retrospective study on Neurosensory disturbance after bilateral sagittal split osteotomy, 15 patients (30 sides) had undergone BSSO during the specified time period. On subjective testing, NSD was reported in 22 operated sides (73.3%) in the immediate postoperative period, while 4 operated sides (13.3%) reported persistent NSD. On objective testing, immediate post-operative NSD was seen in 20 operated sides (66.7%). After a minimum of 1-year follow-up, recovery was seen in 18 operated sides while persistent NSD was seen in 2 operated sides (6.7%). Neurosensory disturbance of the inferior alveolar nerve is a common complication after BSSRO in the immediate post-operative period. However, in a long term, nerve function usually recovers.

S. A. Steenen et al (2016)[41], conducted a study on Bad splits in bilateral sagittal split osteotomy: systematic review and meta-analysis of reported risk factors ,concluded that A meta-analysis pooling the effect sizes of seven cohort studies showed no significant difference in the incidence of bad split between cohorts of patients with third molars present and concomitantly removed during surgery, and patients in whom third molars were removed at least 6 months preoperatively (odds ratio 1.16, 95% confidence interval 0.73–1.85, Z = 0.64, P = 0.52). In summary, there is no robust evidence to date to show that any risk factor influences the incidence of bad split.

S. A. Steenen et al (2016)[40], conducted a study on Bad splits in bilateral sagittal split osteotomy: systematic review of fracture patterns concluded that a systematic review was undertaken, yielding a total of 33 studies published between 1971 and 2015. These reported a total of 458 cases of bad splits among 19,527 sagittal ramus osteotomies in 10,271 patients. The total reported incidence of bad split was 2.3% of sagittal splits. The most frequently encountered were buccal plate fractures of the proximal segment (types 1A–F) and lingual fractures of the distal segment (types 2A and 2B). Coronoid fractures (type 3) and condylar neck fractures (type 4) have seldom been reported. The various types of bad split may require different salvage approaches.

J.C. Posnicket al (2016)[21],conducteda study on Occurrence of a 'bad' split and success of initial mandibular healing: a review of 524 sagittal ramus osteotomies in 262 patients concluded Two hundred sixty-two subjects undergoing 524 BSSROs met the inclusion criteria. Their average age was 25 years (range 13–63 years) and 134 were female (51%). Simultaneous removal of a third molar was performed during 209 of the BSSROs (40%). There were no 'bad' splits. All subjects achieved successful bone union, the planned occlusion, and return to a chewing diet and physical activities by 5 weeks after surgery. The presence of a third molar removed during BSSRO was not associated with an increased frequency of a 'bad' split or delayed mandibular healing.

Jop P. Verweij et al (2016)[26], conducted a study on Risk factors for common complications associated with bilateral sagittal split osteotomy: A literature review and meta-analysis, the mean incidences for bad split (2.3% per BSSRO), postoperative infection (9.6% per patient), removal of the osteosynthesis material (11.2% per patient), and neurosensory disturbances of the lower lip (33.9% per patient) are reported. Regularly reported risk factors for complications were the patient's age, smoking habits, presence of third molars, the surgical technique and type of osteosynthesis material. This information may help the surgeon to minimize the risk of these complications and inform the patient about the risks of complications associated with bilateral sagittal split osteotomy.

W. Semper-Hogg et al (2017)[52], the influence of dexamethasone on postoperative swelling and Neurosensory disturbances after orthognathic surgery: a randomized controlled clinical trial, Patients undergoing orthognathic surgery should receive a preoperative injection of Dexamethasone in order to control and reduce edema. However, there was no influence of dexamethasone on reduction of neurosensory disturbances.

Valthierre Nunes de Lima et al (2017)[48], conducted a study on The Effectiveness of Corticosteroids Administration for Edema and Neurosensory Disturbance in Orthognathic Surgery, the effect of corticosteroid (CS) administration on edema and neuroregeneration in orthognathic surgery. We conducted a systematic literature search using three databases (PubMed/Medline; Cochrane Library; Scopus). We utilized the PICO approach, which includes four parts: (P) Population, patients with skeletal dentofacial deformity; (I) Intervention, uni- or bimaxillary orthognathic surgery; (C) Comparison, corticosteroids administered or not; (O) Outcomes, reduction in postoperative edema and neurosensory disorders. We selected 30 items from a total of 240 and evaluated them for their titles and abstracts in relation to the inclusion and exclusion criteria. After we eliminated duplicate references, we were left with 8 articles. We observed lower rates of edema in patients that used corticosteroids. In fact, after 4 months, there was no remarkable edema rates. These results suggest that neurosensory disorders improved in periods longer than 3 months. In addition, in both the early and late periods, administration of corticosteroids did not influence the regression of neurosensory disorders. Inconclusion, administering corticoids in orthognathic surgery improved the regression of facial edema independent of the dosage used, but did not influence neurosensory disorders.

Eduardo Sant Ana et al (2017)[13], conducted a study on Lingual Short Split: A Bilateral Sagittal Split Osteotomy Technique Modification, the short lingual split technique modification was Initially described for patients with narrow jaw with a thick cortical bone and thin medullar bone, with potential risk of undesirable sub condylar fractures during the handling and the opening with forceps and the Smith separators. The surgical procedure follows the common steps of the conventional surgical technique, described in literature,5–13 with mucosal incision over the external oblique line, mucoperiosteal detachment to the mandibular basal across buccal surface, from the ramus region until we reach the mental nerve. It is held also the carefully mucoperiosteal detachment in the lingual region of the mandibular ramus, identifying the mandibular lingula and inferior alveolar neurovascular bundle, but without manipulating it. From this point on, we propose a modification, as the technique originally describes the horizontal osteotomy 0.5 cm above the nerve/lingual. Our proposal is the low horizontal osteotomy performed with drill 4.0 to 5.0mm in diameter, weakening the cortical area until we reach the most fragile region located below the mandibular lingula, and then the osteotomy starts with a short saw over the cortical bone. We performed a sagittal osteotomy with a surgical saw until we reach the distal face of the first molar and the downward vertical mandibular osteotomy to the mandibular basal, perpendicular to the sagittal, such as described by Hunsuck. At this part, an osteotomy at the inferior border with 2- to 3-mm depth into the lingual cortical will unite the vertical osteotomy as described by Wolford et al. Carefully, we open the sagittal osteotomy with chisels, without traumatizing the inferior alveolar nerve, separating the 2 bone fragments, proximal and distal. To the mandible set back movement, a vertical osteotomy is performed to adapt the new position of the mandible. The difference of this new technique is that the sagittal fracture in the mandibular lingual region would have a horizontal, inferior, and parallel trajectory to the entrance of the inferior alveolar bundle, and not posterior and superior like in the original technique, so that the nerve would be free after the osteotomy, without tension, with little manipulation, and the mandibular basal preserved, maintaining the pteregomasseteric muscle insertion, helping preserve the Condyle position. Others benefit would be decreasing the risks of undesirable fractures in the superior direction or the subcondylar region, as most weakness will occur lingually and inferiorly, toward the mandibular basal.

S.C. Mohlhenrich et al (2018)[44], conducted a study on Evaluation of the lingual fracture patterns after bilateral sagittal split osteotomy according to Hunsuck/Epker modified by an additional inferior border osteotomy using a burr or ultrasonic device. This study was conducted to compare fracture patterns and operation times after sagittal split osteotomy (BSSRO) by

Hunsuck/Epker approach, performed using a burr or ultrasonic device, with and without osteotomy modification. A total of 80 BSSROs were performed in fresh human cadavers using a burr or ultrasonic device to investigate the influence of surgical instruments as well as an additional bone cut on the inferior border of the mandible in terms of lingual fracture patterns. The times required for osteotomy and sagittal split were measured, and postoperative cone beam computed tomography images of all splits were analysed. Without an additional inferior osteotomy, preferred splits according to Hunsuck/Epker were achieved in 35% of cases (7/20) with the burr and 45% (9/20) with the ultrasonic instrument. The inferior modification resulted in a greater number of unwanted fracture patterns in both groups. There was no relationship between the split technique and the fracture pattern. Statistically significant differences in osteotomy time were observed between bur osteotomy and modified burr osteotomy , as well as modified ultrasonic osteotomy , but not between bur and ultrasonic surgery both without the inferior cut . The bone cut on the inferior border did not improve split control, but rather increased the risk of unwanted fractures and extended the operation time.

Materials and Methods

MATERIALS AND METHODS

This study was conducted at the Department of Oral and Maxillofacial Surgery, Ragas Dental College. The study was done to evaluate the influence of additional osteotomy at the inferior border of the mandible in addition to the classical Obwegeser and Dal-Pont technique of BSSRO. The physio elastic properties of the dry mandible would be different from that of fresh or alive mandible. So, we included fresh goat mandible in the study as a control group. Ethical clearance was obtained from The Institutional Review Board prior to commencing the study.

INCLUSION AND EXCLUSION CRITERIA

<u>INCLUSION CRITERIA:</u>

A total of 15 adult dry human cadaveric mandible without an impacted third molar were included and 15 fresh goat mandible (sacrificed for the food) which acted as control group were also included.

<u>EXCLUSION CRITERIA:</u>

The mandible with pathological condition or damaged condition were excluded from the study.

MATERIALS

- Micromotor,
- Straight hand piece. Fig-1
- 703 bur, 701 bur, 559 bur.
- BP Blade with handle
- Periosteal elevator
- Osteotome -fine thin osteotomes
- Mallet
- Spreader
- Specially designed Torque gauge attached with the Spreader Fig-2

DIGITAL GAUGE AND ITS SOFTWARE: (Fig- 2)

The clipper is fixed with load cell of 1 kg capacity and tightened with M3 screws. The handle where pressure is applied is fixed with load cell of 1 capacity. These load cell can measure force applied on it upto 10 N force or 10 Kgf. From the load cell the values are taken to Wheatstone bridge circuit or HX711 circuit for converting analog signals or resistance received from the load cell and convert it to digital signal. These digital signals are taken to the controller unit. The purpose of the controller unit is to send the signal to the display interface. The signal received from the HX711 is sent to computer / laptop using USB Ethernet data cable. Arduino Software (IDE) is used to detect the readings and program is done in this software for the load cell force calculation. Then standard weights are taken to calibrate the load the cell using the software and adjust the readings. After calibrating the load cell, it is fixed in the tool handle.

GOAT ANATOMY

The two halves of the mandible articulate by a moveable cartilaginous symphysis well into advanced age. The ventral border of the body is convex and the notch for the facial vessels is indistinct. The short incisive part bears the alveoli for the incisor teeth (Three on each side) which is followed immediately by one for the canine tooth. The interdental space has particularly sharp border. This is succeeded by the molar part which carries six alveoli for the cheek teeth. The mental foramen can be palpated through the skin of the lower lip on the lateral surface of the mandible, a fingers breadth behind and below the canine tooth. The mandibular foramen which is the entrance to the mandibular canal, lies on the medial surface of the ramus at the point of intersection between a vertical line drawn from the lateral canthus of the eye and one drawn caudally for the palpable edge of the maxillary cheek teeth. The mandibular head of the condylar process is transversely concave while the coronoid process is curved backwards (Fig-3).

METHODS

The mean distance from the mandibular foramen to inferior, anterior, posterior border of ramus and to the sigmoid notch were evaluated and recorded. The mean parallel distance between the mandibular foramen and mental foramen were also measured.

SURGICAL TECHNIQUE

The Bilateral sagittal split osteotomy was performed in each mandible according to Obwegeser-Dal Pont technique on the left side and with an additional inferior border osteotomy in the right side (Fig-4).

OBWEGESER AND DALPONT TECHNIQUE:

The horizontal medial osteotomy was made just above the mandibular foramen through the cortical bone of the ramus. The vertical osteotomy was done at the lateral cortical bone mesial to the second molar tooth from the lower border of the mandible to the external oblique ridge. The horizontal medial cut and vertical lateral osteotomy cuts were connected by the oblique osteotomy cut running along the external oblique ridge. The lateral vertical osteotomy cut was extended as J cut at the inferior border to extend till the lingual side. In the goat mandible, the lateral vertical bony cut was performed at two-thirds of the total length distal to the mental foramen to mandibular foramen. A 703 or 702 surgical carbide bur was used for all of the osteotomies. After the osteotomy cuts were completed, an osteotome with an 18-mm width was inserted distal to the second molar at an angle of 45 degrees was driven into the mandibular body in the cranio-caudal direction no deeper than 2/3 of that length, and the entire osteotomy was deepened and gradual separation of the buccal cortical plate from the distal segment was done. Then proximal and distal segments were splitted using smith's spreader attached with a Torque gauge. The maximum torque force that was needed to split the mandible was recorded in computer and the fracture pattern was observed.

MODIFIED BSSO TECHNIQUE WITH INFERIOR BORDER OSTEOTOMY:

The right side of each mandible was operated in a modified manner by an additional osteotomy at the inferior border of the mandible from the anterior vertical cut to the mandibular angle region in addition to the classical Obwegeser- Dalpont technique. The osteotome was applied in a similar manner and the fracture pattern and force required to split the mandible were observed and recorded.

MODIFIED LINGUAL SPLIT SCALE:

To categorize the different split patterns a lingual split scale (LSS) was developed. The LSS consisted of 5 categories based on the path of the fracture line on the lingual side of the ramus (Fig – 5). In all cases, the split began at the distal end of the medial bone cut and followed one of the following paths:

- Type 1: The lingual fracture line started above and just behind the mandibular foramen and remained posterior and inferior to the mandibular canal but without the involvement of the lower border of the mandible. The lingual plate sagittally split above the level of the lower border of the mandible.

- Type 2: The lingual fracture line started above and just behind the mandibular foramen and extended to the lower border and connected with the inferior border osteotomy resulting in sagittal splitting of the mandible through the middle of the inferior border of the mandible. The fracture line was posterior and inferior to the mandibular canal.
- Type 3: The lingual fracture line extended to the posterior border of the mandible and splitted the entire ramus of the mandible and extended anteriorly above or along the lower border of the mandible.
- Type 4: The posterior fracture line started above and just behind the mandibular foramen and extended anteriorly in the mylohyoid groove or through the mandibular canal.
- Type 5: The unfavorable split resulting in fracturing of the ramus, angle or buccal cortex of the mandible.

The digital torque gauge was used to record the force necessary to split the mandible.

Figures

FIG.1 ARMAMENTARIUM

Fig 1a. MICROMOTOR & HANDPIECE

Fig 1b OSTEOTOMES

FIG.2 SPECIALLY DESIGNED TORQUE GAUGE

Fig 2 a. SMITH SPREADER ATTACHED TO THE TORQUE DEVICE

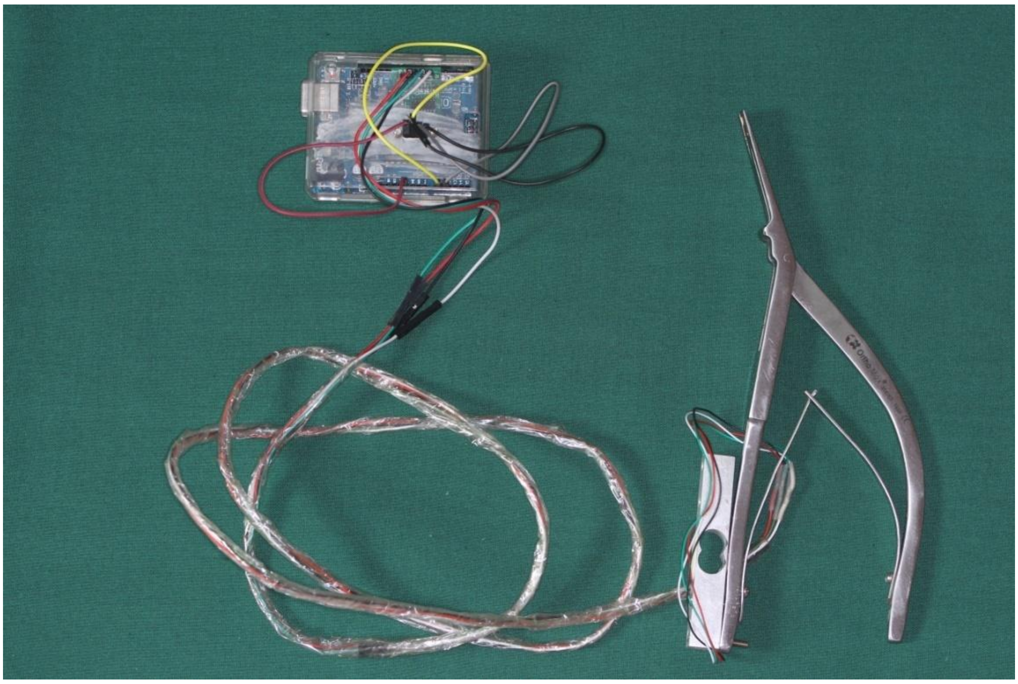


Fig-2 b. LOAD CELL

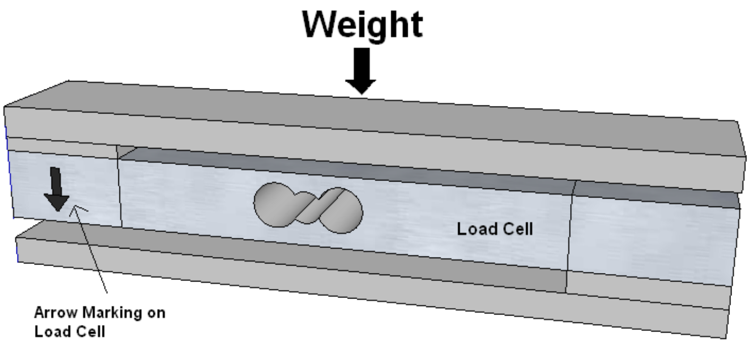


Fig-2 c. HX 711 CIRCUIT AND CONTROLLER / DISPLAY CIRCUIT BOARD

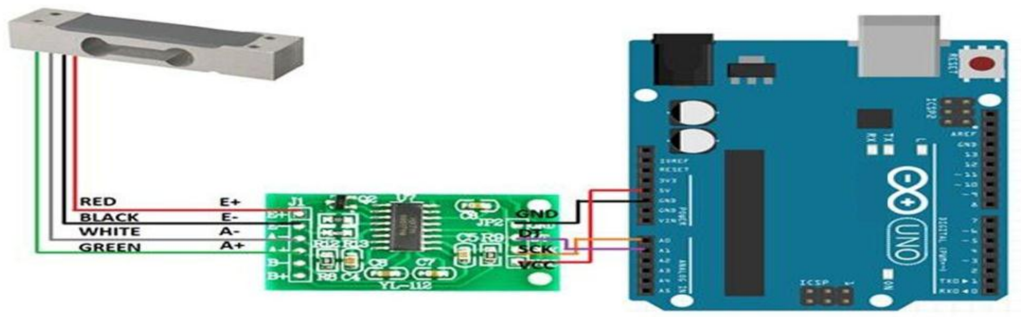


Fig.2 d. SCREENSHOT OF THE RECORDED TORQUE FORCE

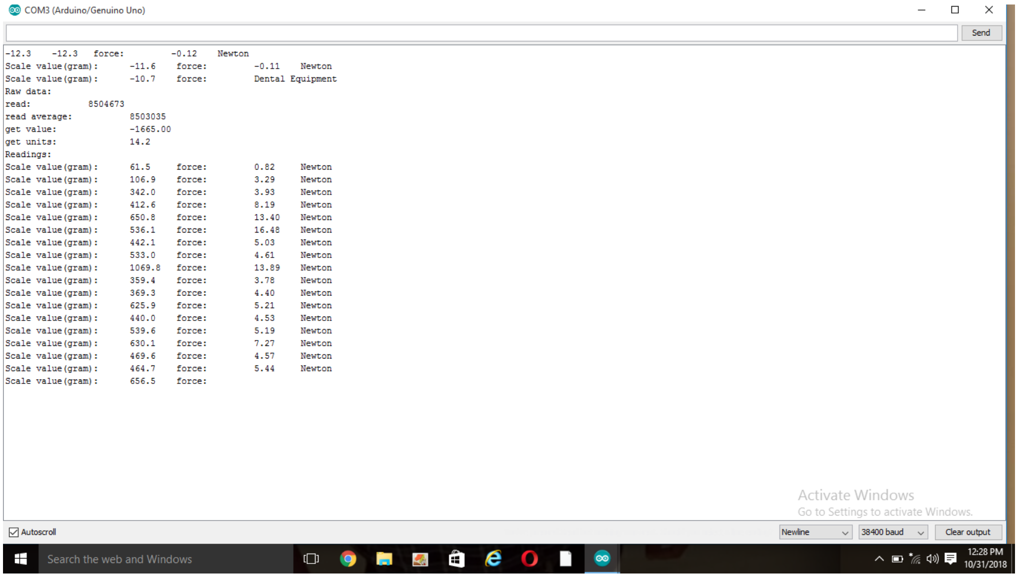


FIG-3 GOAT MANDIBLE LATERAL ASPECT

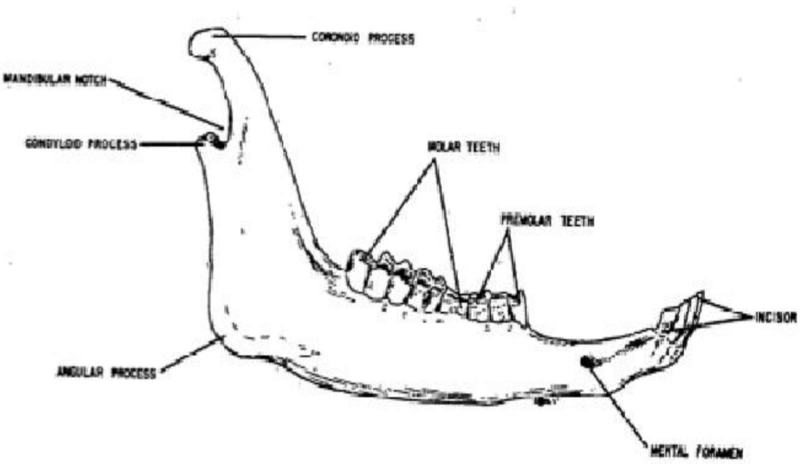


FIG 4 SURGICAL TECHNIQUES

Fig 4 a. HORIZONTAL MEDIAL CUT

Fig 4 b. LATERAL VERTICAL OSTEOTOMY CUT

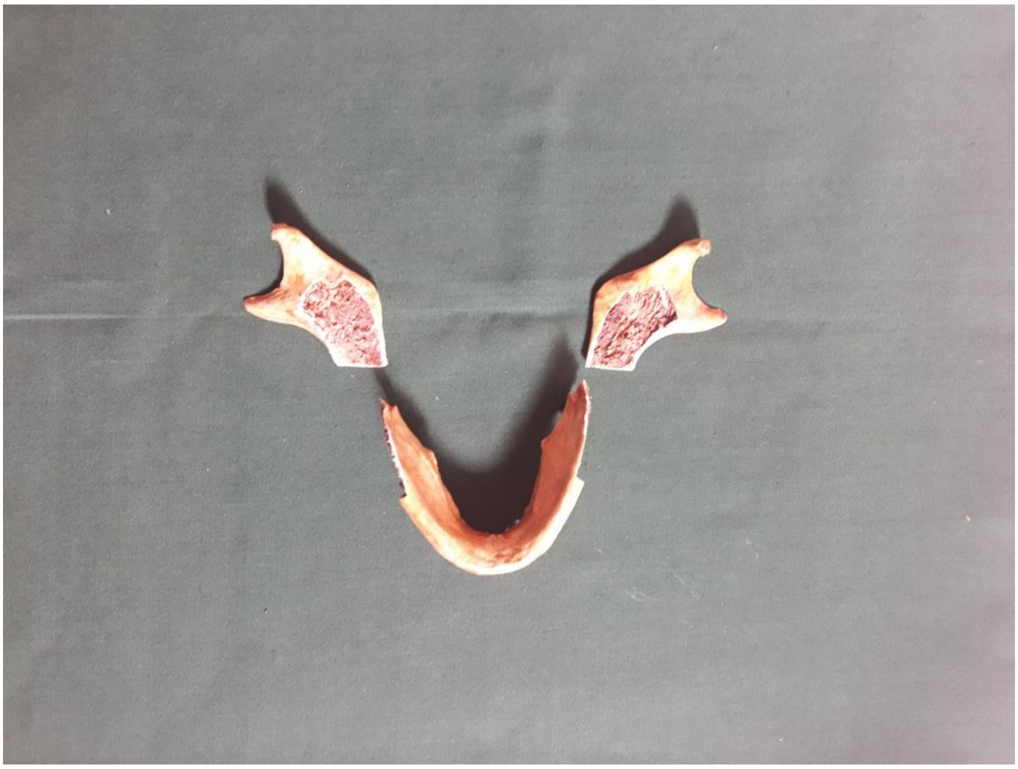
Fig 4 c. OBLIQUE CONNECTING OSTEOTOMY CUT

Fig 4 d LOWER BORDER “J” OSTEOTOMY CUT
ADDITIONAL INFERIOR BODY OSTEOTOMY CUT

Fig 4 e APPLICATION OF SPREADER

Fig 4 f LINGUAL SPLIT OF THE MANDIBLE –RIGHT SIDE AND LEFT SIDE (ALVEOLAR)

Fig 4 g LINGUAL SPLIT OF THE MANDIBLE –RIGHT SIDE AND LEFT SIDE (INFERIOR BORDER)



GOAT MANDIBLE

Fig 4 h. LATERAL VERTICAL CUT

Fig 4 i . OBLIQUE CUT

Fig 4 k. RIGHT SIDE SHOWING ADDITIONAL OSTEOTOME(INFERIOR CUT) LEFT SIDE SHOWING (J CUT)

Fig 4 i. APPLICATION OF SPREADER

Fig 4 j. GOAT MANDIBLE MEDIAL SIDE OF RIGHT

SIDE (ADDITIONALOSTEOTOMY)

Fig 4 k. GOAT MANDIBLE MEDIAL SIDE OF LEFT

SIDE (J CUT)

Fig 5 LINGUAL SPLIT SCALE

Fig.5 a. TYPE -1

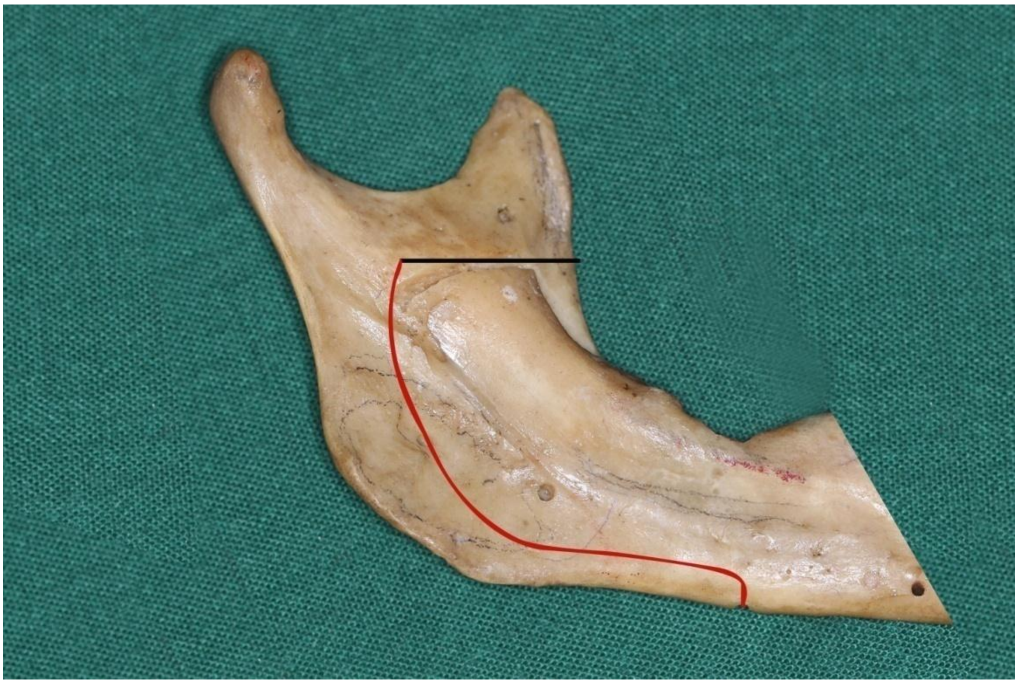


Fig 5.b.TYPE-2

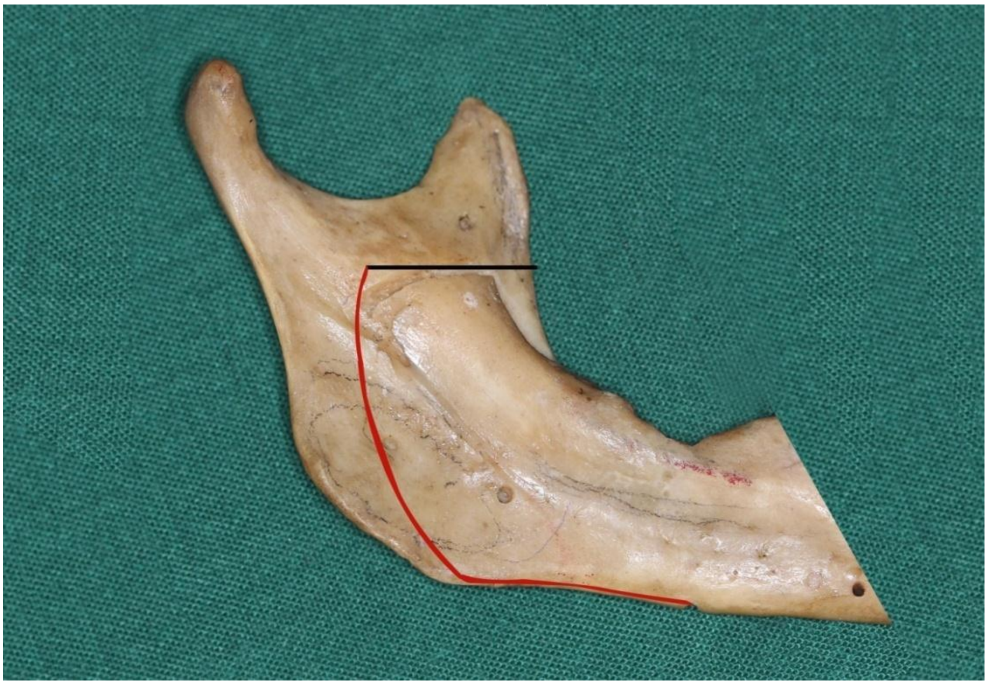


Fig.5c. TYPE-3 A

Fig 5 d TYPE-3 B

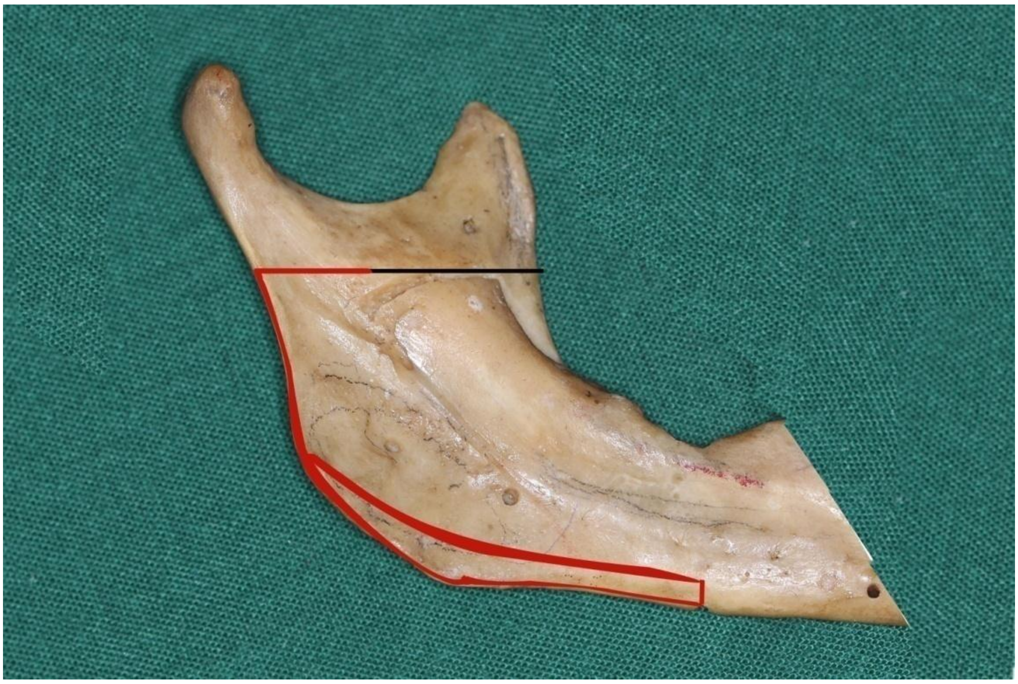


Fig 5.e TYPE-4

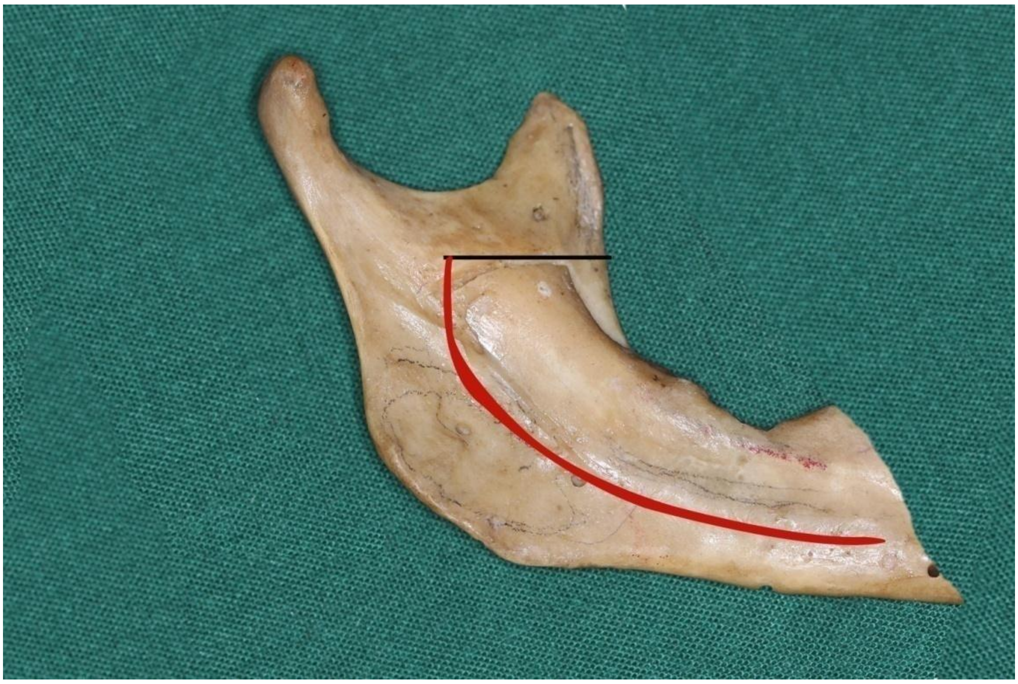
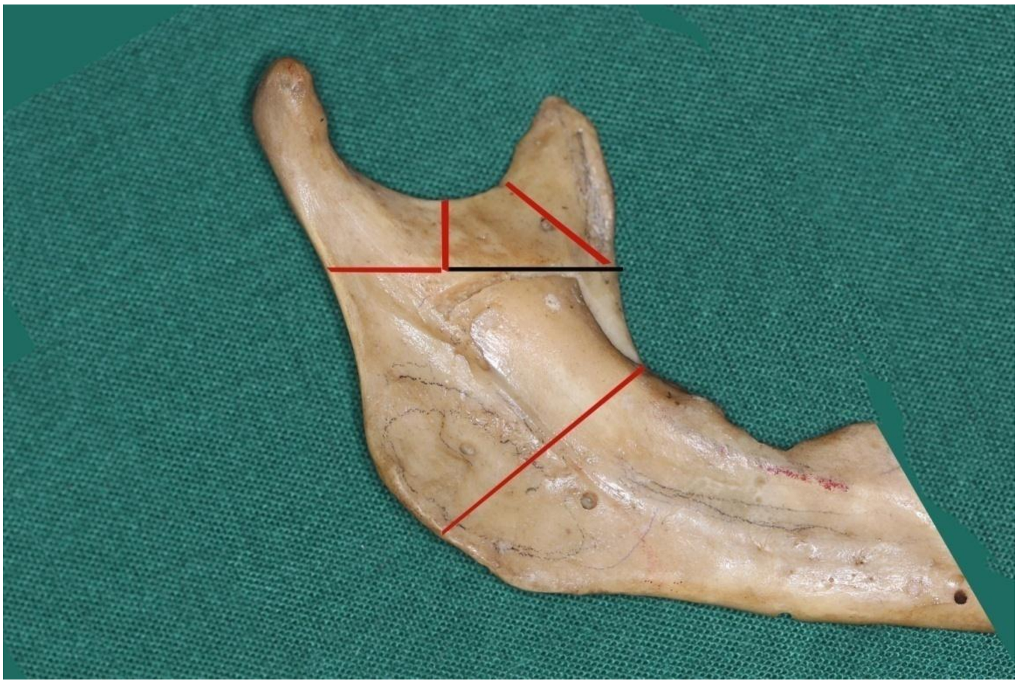


Fig f. TYPE-5



Results

RESULTS

The present study aimed at evaluating the lingual fracture pattern after Bilateral Lateral Sagittal Split Osteotomy (BSSRO). The study included a total of 30 mandibles, out of which 15 were Cadaveric Dry Mandibles and 15 were Goat mandibles. The goat mandibles were included in the study because the physio elastic properties of dry mandible would be different from that of fresh alive human mandible. So fresh goat mandibles were included in the study as control group to evaluate whether the outcome was due to the influence additional inferior body osteotomy cut or due to the changes in the mechanical properties of the mandible.

BSSO were performed in both the groups. The mandibles from both groups (Cadaveric and Goat Mandible) were assigned for two types of BSSRO techniques. The right side was assigned with “BSSRO with Inferior Border cut” (Modified Technique) and Left side was assigned with “BSSRO with J-cut” (Obwegeser Dal Pont’s Technique) as described in the methodology.

Statistical analysis of the data obtained was done using SPSS 22 software. The Frequency of distribution of fracture patterns were calculated in both the groups. Also, descriptive statistics such as mean and standard deviations [SD] were calculated for the torque force observed in both the groups. We used Mann Whitney U test to observe the significance in the frequency of distribution of fracture patterns in both the groups and p-value less than 0.05 were considered statistically significant. We use Independent t-test to analyze the significance between torque forces measured in both the techniques (Obwegeser Dal Pont’s and Modified Technique) in both the groups and p-value less than 0.05 were considered statistically significant.

The mean distance from the mandibular foramen to anterior border, posterior border, sigmoid notch, inferior border and parallel distance with mental foramen were evaluated and measured. We observed that there was no significant difference in the descriptive data between right side and left side in both goat and human cadaveric mandible. All the mandibles were symmetric in nature. (Table 1, Table 4)

CADAVERIC DRY MANDIBLE

With the Obwegeser Dal Pont technique in the cadaveric dry mandible we recorded an average torque of 12.6 ±2.4 Nm (SD: 0.32) with a maximum of 16.0 Nm and a minimum of 8.0 Nm. When using the modified technique with an additional osteotomy at the inferior border we recorded a maximal torque of 12.0 Nm and a minimal torque of 5.0 with an average required torque of 8.7 ± 2.1 Nm. The new technique decreased the torque needed to split the jaw by 31 % when compared to the classical BSSO technique. The decrease in the torque required to complete the split with the additional lower rim osteotomy was statistically significant.

With the Obwegeser Dal Pont technique in the cadaveric dry mandible 80% of the mandible were Type I fracture pattern and 20% had Type III fracture pattern. In contrast with the modified technique with an additional osteotomy at the inferior border of the mandible 93% of the cases split by Type II fracture. The creation of a new osteotomy at the lower border of the mandible improved the ability to control the splitting process in a more predictable manner with reduced force. The use of the Obwegeser Dalpont BSSRO technique frequently causes a fracture line near the mandibular canal predisposing to higher risk of nerve injury.

GOAT MANDIBLE:

The average force required to complete the split after the completion of osteotomy was 16.5 N ± 2.8N (Range 21 N to 12 N) in Obwegeser DalPont technique in comparison to 9.2 N ± 2.9 N (Range 6N to 18 N) for BSSRO cut with inferior body osteotomy. The new technique decreased the torque needed to split the jaw by 40 percent when compared to the Obwegeser Dal Pont BSSO technique. The decrease in the torque required to complete the split with the additional lower border osteotomy was statistically significant. The same trends were noted with the splitting patterns. Most of the hemi-Mandibles (80%) split by type I fracture pattern in the Obwegeser-Dal Pont technique surgical protocol. By adding the inferior border osteotomy, the mandibular split was more predictable and 100% the hemi-mandibles split by Type II fracture pattern. The study outcome in the dry mandible correlates with that of the goat mandible indicating the influence of the modified osteotomy in the fracture pattern of the mandible.

Tables and Charts

HUMAN CADAVERIC DRY MANDIBLE

Table 1: HUMAN CADAVERIC DRY MANDIBLE DESCRIPTIVE DATA

Variables	**Right side (mm)**	**Left side (mm)**	**Mean Difference (independent sample t test)**	**P Value**
ANTERIOR BORDER TO MANDIBULAR FORAMEN	19.13± 2.1	19.07± 1.7	.067	.925
MANDIBULAR FORAMEN TO POSTERIOR BORDER	12.60± 3.0	13.00± 3.0	-.400	.721
SIGMOID NOTCH TO MANDIBULAR FORAMEN	15.47± 2.5	15.20± 3.1	.267	.798
MANDIBULAR FORAMEN TO INFERIOR BORDER	25.47± 3.9	26.53± 2.8	-1.067	.397
CONDYLAR HEIGHT	18.33± 2.4	18.80± 1.8	-.467	.545
CORONOID HEIGHT	16.93± 1.9	17.27± 1.5	-.333	.598
MANDIBULAR FORAMEN TO MENTAL FORAMEN	50.87± 5.5	51.07± 4.3	-.200	.913

Table 2. DESCRIPTIVE STATISTICS FOR TORQUE FORCE ON THE CADAVERIC DRY MANDIBLE (INDEPENDENT t-test)

	Minimum (N)	**Maximum (N)**	**Mean**	**SD**	**P – value**
BSSO with inferior border cut (Right side)	5.00	12.00	8.7333	2.12020	0.000023
BSSO without inferior border cut (Left side)	8.00	16.00	12.6667	2.35028	

Table 3. MANN WHITNEY U TEST FOR THE FREQUENCY OF DISTRIBUTION OF FRACTURE PATTERNS IN CADAVERIC DRY MANDIBLE AMONG TYPE OF TECHNIQUE

	Total	**Type I (n)**	**Type II (n)**	**Type III (n)**	**Type IV (n)**	**Type V (n)**	**p-value**	**Significance**
BSSO with inferior border cut (Right side)	15	1	14	0	0	0	0.840	Not Significant at $p < 0.05$.
BSSO without inferior border cut (Left side)	15	12	0	3	0	0		

Chart 1: DISTRIBUTION OF FRACTURE TYPE IN CADAVERIC DRY MANDIBLE

(RIGHT SIDE VS LEFT SIDE)

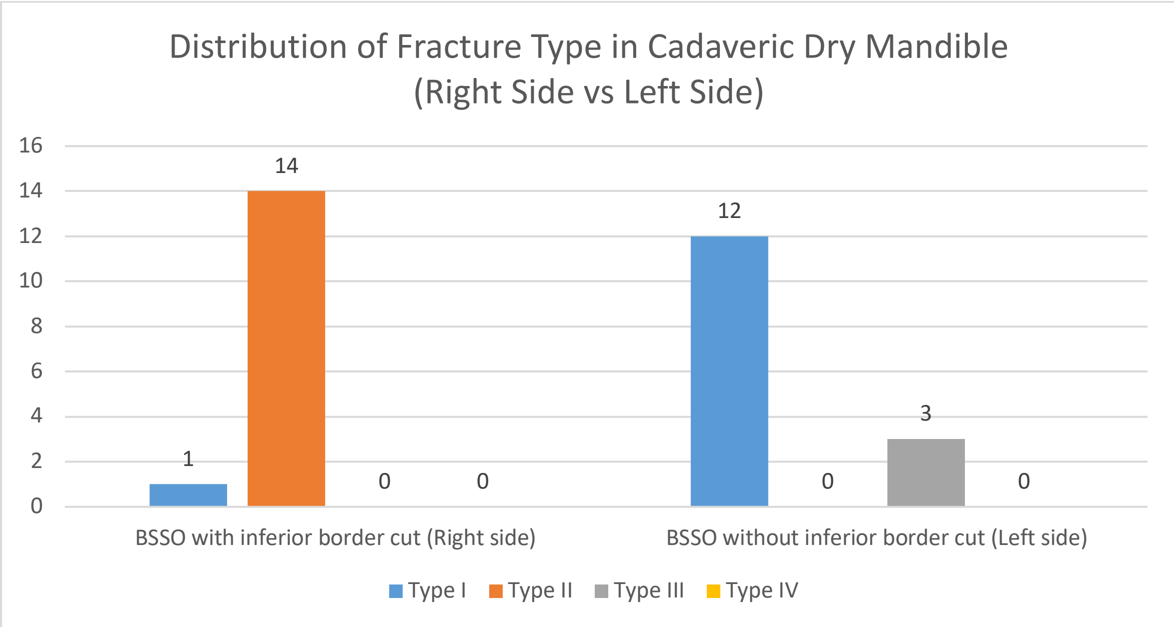
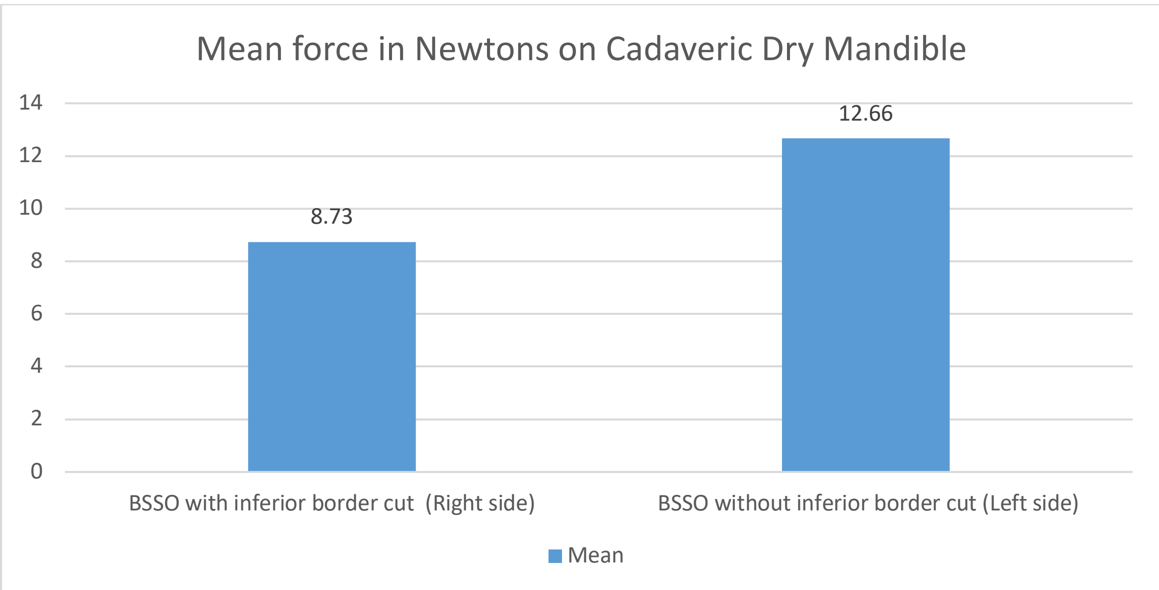


Chart 2: MEAN TORQUE FORCE IN NEWTON ON CADAVERIC DRY MANDIBLE



GOAT MANDIBLE

Table 4: GOAT MANDIBLE DESCRIPTIVE DATA

Variables	**Right side (mm)**	**Left side (mm)**	**Mean Difference (independent sample t test)**	**P Value**
ANTERIOR BORDER TO MANDIBULAR FORAMEN	12.60± 2.3	12.27± 1.9	.333	.671
MANDIBULAR FORAMEN TO POSTERIOR BORDER	13.73± 2.4	13.87± 1.6	-.133	.859
SIGMOID NOTCH TO MANDIBULAR FORAMEN	25.33± 3.2	24.80± 3.3	.533	.658
MANDIBULAR FORAMEN TO INFERIOR BORDER	28.07± 3.0	27.60± 1.2	.467	.586
CONDYLAR HEIGHT	13.27± 2.1	13.20± 2.1	.067	.932
CORONOID HEIGHT	27.20± 2.4	27.20± 2.0	.000	1.000
MANDIBULAR FORAMEN TO MENTAL FORAMEN	98.93± 5.4	99.53± 4.0	-.600	.733

Table 5: DESCRIPTIVE STATISTICS FOR TORQUE FORCE ON GOAT MANDIBLE.(INDEPENDENT t-test)

	Min (N)	**Max (N)**	**Mean**	**SD**	**p-value**
BSSO with inferior border cut (Right side)	6.00	18.00	9.2000	2.90812	< .00001
BSSO without inferior border cut (Left side)	12.00	21.00	16.5333	2.79966	

Table 6: MANN WHITNEY U TEST FOR THE FREQUENCY OF DISTRIBUTION OF FRACTURE PATTERNS IN GOAT MANDIBLE AMONG TYPE OF TECHNIQUE

	Total	**Type I (n)**	**Type II (n)**	**Type III (n)**	**Type IV (n)**	**Type V (n)**	**p-value**
BSSO with inferior border cut (Right side)	15	0	15	0	0	0	
BSSO without inferior border cut (Left side)	15	12	3	0	0	0	1.000

Chart 3: DISTRIBUTION OF FRACTURE TYPE IN GOAT MANDIBLE (RIGHT SIDE VS LEFT SIDE)

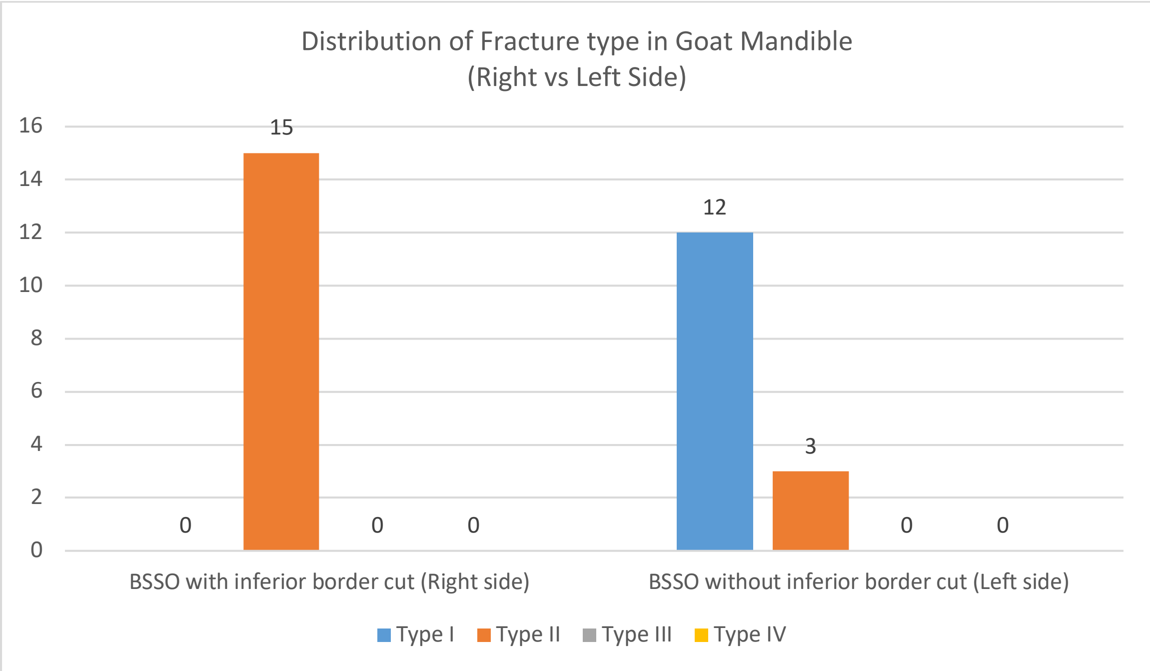
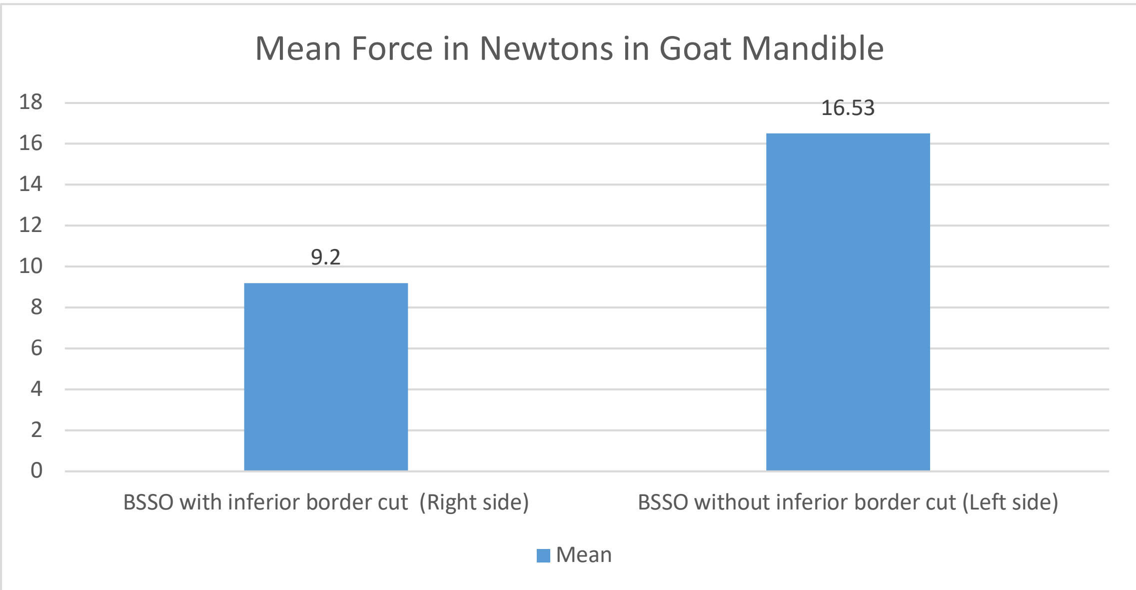


Chart 4: MEAN TORQUE FORCE IN NEWTON ON GOAT MANDIBLE



Discussion

DISCUSSION

Sagittal split Osteotomy is considered to be the most established surgical technique used in orthognathic surgeries. Even though numerous modifications have been made, the conventional technique remains unchallenged as the sort out technique in orthognathic surgical procedure. The modifications applied to this technique have been done to reduce or overcome complications associated with the surgical procedure. Some of the modifications have been associated in improving the esthetic outcome of the surgery.

Jop P. Verweij et al[25] conducted a human cadaveric study on Angled Osteotomy Design Aimed to Influence the Lingual Fracture Line in Bilateral Sagittal Split Osteotomy, In the angled osteotomy group, the modified osteotomy design was used , which included thehorizontallingual and connecting sagittal bonecuts. The modification was the use of an angled verticalbuccal bone cut making an angle of approximately 45 degree with the inferior border of the mandible. This angled buccal bone cut originated from the of the second molar, extending toward the mandibular angle and ending near the masseteric tuberosity. Therefore, the inferior border cut waspositioned near the masseteric tuberosity and subsequently aimed in a posterior direction.The advantages of the angled osteotomy design promote a more posterior lingual fracture originating from the inferior border cut and a trend was apparent that this also might decrease the incidence of bad splits and Inferior Alveolar Nerve entrapment. Common surgical complications during the surgery are damage to inferior alveolar nerve and unfavorable splits, the complications which are suggested to be related to each other.

In theory, the more a technique facilitates to weaken the mandible in proportion to the depth of the osteotomy performed, the better it improves the outcome of the splitting process. Modifications in this approach may only allow adding osteotomies of the inferior and posterior borders to the Classic Obwegeser procedure. The suggested modifications itself may be difficult mainly due to lack of ease in access to those regions with an intra oral approach; however, an osteotomy in the inferior border is achievable and is easily accessible than the posterior border of the mandible. There are not many studies that address the biomechanics of BSSRO to optimize the technique and in prevention of surgical complications.

Several investigators have described the influenceof the osteotomy design on the lingual fracture line. Plooij et al showed that a longer horizontal lingualbone cut ending behind the anterior border of themandibular foramen resulted in more LSS1 splits (i.e a more posterior splitting pattern). Plooij et al[22] investigated mandibular ramus split patterns using three-dimensional computed tomography (3D-CT), and reported that in 83.75% splits at the lingual side of the mandibular ramus, only 51.25% of the splitlines ran according to Hunsuck's description, whereas 32.5% ran through the mandibularcanal. 13.75% splits were at the posterior border of the mandibular ramus, and 2.5% were otherfracture patterns (including buccal plate fracture or a bad split). We were able to observe the frequency of distribution of splitting patterns in both the groups and also their significance. In our study, we observed that by adding osteotomy in the inferior border, the mandibles fractured in a more predictable manner away from the nerve and along the inferior border of the mandible.

There are two points at which there is increased risk of damage to the IAN during surgical splitting; during manipulation of the medial side of the ramus and during fracturing, splitting. Majority of the authors have reported post-operative sensitivity deficits due to manipulation close to the IAN. A weakened mandibular body with additional osteotomy procedure could reduce the manipulation time on the lingual aspect, also preventing the need to chisel around the IAN because of the preformed splitting pattern, and it also could help to reduce the operative time. Such complications can be minimized by adding the inferior border osteotomy. We were able to achieve good splitting results with the modified technique in our study setting.

Recently, software platforms have been introduced to reconstruct a 3D model from (cone-beam) CT data to analyze 3D data in a virtual operating room (VOR). With these 3D models, a clear view of the lingual surface of the mandible can be achieved, enabling observation of thepreviously hidden lingual aspect of the fracture line.CBCT based evaluation of the BSSRO combined with the lingual split scale enabled objective evaluation of the surgical result, thereby adding a new dimension to the discussion of BSSRO techniques. On examining the split patterns of the mandibular ramus in BSSRO through cone-beam computed tomography(CBCT) the investigators hypothesized that the thickness of the cortical bone of the ramus, the degree of the mandibular angle and the shapes of the mandibular ramus in the axial plane could beassociated with these split patterns.In our study, we also measured the torque force used in the resulting fracture patterns. The Modified BSSRO Technique with inferior border osteotomy resulted in30% to 40% reduction of forcerequired to split the mandible. It was correlating with the studies of Roland Böckmann[6].In his study the device HTG2-10 gauge developed by IMADA (Toyohashishi, Japan) has been used to evaluate the force required to split the mandible. Its accuracy was ±0.5%, with a measurement frequency of 33 times per second. Theapplied force was recorded with a PC and ZLINK 2 software, international edition,version 2.02E, obtained from IMADA.

Muto et al[36] evaluated the mandibular ramus BSSRO split patterns with Obwegeser and DalPont technique using CBCT and reported 63% splits at the lingual side, 22% splits at the posterior border, and 15% splits at the buccal side of the mandibular ramus. Majority of the mandibular ramus split at the lingual side near the mylohyoid sulcus; while the remaining split at the posterior border of the mandibular ramus. No fracture lines were observed through the mandibular canal. In terms of the relevant anatomical features that influenced the split patterns, Plooij et al[22] suggested that the split pattern was related to the end-position of the medial bone cut. Reyneke et al and Kriwalsky et al[27]reported that the split pattern is also influenced by the presence of the third molar and the patient’s age. In general, fractures or splits usually occur in a weaker region in terms of structure and biomechanics. The thinner the cortical bone, the weaker it is biomechanically, and therefore, easier to split. Ma et al reported that the lingual cortical is thinner than the buccal cortical. Hence, most of the splits (75.38%) ran as described by Hunsuck.

Ma et al also found that the shapes of the mandibular ramus in the axial plane varied among patients. In majority of the patients, the mandibular ramus is wider medio-laterally in the anterior border than the posterior border, but the width in the anterior and posterior border is similar in few patients. Ma et al also classified mandibular ramus into three types: the half-crescent, sim-triangle shapes (with wider anterior region as compared to the posterior region), and the well-distributed shape (with similar width of the anterior and posterior regions). The half-crescent and sim-triangle shapes have higher chances of Vertical pattern of fracture line to inferior border of the mandible during BSSRO. However, the mandibular ramus usually split at the posterior border in the well distributed pattern. The mandibular angle contains less cancellous bone and more cortical bone. The attachment of the medial pterygoid and the masseter muscles in the mandibular angle compacts the medial and lateral plates in the mandibular angle region. The differential distribution and transmission of stress with respect to the different shapes of the mandible could be one of the reasons for the different split patterns of the mandibular ramus. But in our study, we have not evaluated the influence of mandibular angle on the fracture pattern.

Hou M[18] studies have shown that the distribution and transmission of stress could be altered by an additional osteotomy at the inferior border of the mandible in the BSSRO. The torque needed to split the mandible could increase if the degree of the mandibular angle is less. During the surgery they found that the mandibular body was initially split, and then the mandibular ramus was split gradually. When only the mandibular body is split, most of the mandibular ramus split smoothly near the mylohyoid sulcus in the hyperdivergent patients[18]. In contrast, due to the larger curvature of the mandibular angle in the hypodivergent patients, it is difficult to split the mandibular ramus at the lingual side near the mylohyoid sulcus[18]. In order to split the mandible completely in the hypodivergent patients, a deeper split is needed in the region of the mandibular angle and the mandibular ramus.

Along with the decreased force required to split the bone, adding an osteotomy at the lower border of the mandible also improved the ability to control the splitting process. Although, the outcomes of our study have been found to be significant and favorable, application of the modified technique must be done careful as it may be technique sensitive. It is also necessary to consider the bio-mechanical characteristics of dry cadaveric human mandible would be different from that of alive human mandible. To further recommend the use of the technique in clinical operative conditions, it may be relevant to consider using instrument that could easily facilitate a safe method to make an inferior border osteotomy via intra-oral approach. A notable suggestion would be the use of piezoelectric equipment with a hooked oscillating saw to facilitate an inferior border osteotomy. A rotating or oscillating saw could be used. Wolford and Davis[50] developed areciprocating saw to cut the inferior border of the mandible in 1990. Using this they achieved mandible splitting without malleting. They described a more predictable split with fewer complications. The marginal branch of the facial nerve should be considered while attempting the technique in patients. According to the authors, this technique should only be used by experienced surgeons to avoid complications.

Gruber et al and Ueki et al[38] described minor nerve impairment and a reduction in bleeding when using the piezo device for osteotomies. Piezosurgery does not guarantee a safe bone split and is time consuming. Another possibility is the use of the Wethington osteotomes. These were designed by Simpson to facilitate horizontal osteotomies but also aid osteotomy of the inferior border. The osteotomy was achieved using a triangular, v-shaped osteotome without soft tissue protection provided by the instruments themselves. Application of our modified technique with such proper armamentarium may produce a better and predictable outcome. However, it should also be considered that the split patterns are also influenced by the surgical factors including the experience of the surgeon performing the procedure along with the force and direction of the split. A randomized control trial with suggest instruments and in a standardized operating protocol will serve to be significant in establishing the technique.

In our study we found that this modified BSSRO technique resulted in more predictable pattern of lingual fracture pattern along the lower border of the mandible away from the mandibular canal and with the less required force to split the mandible. However the drawbacks of the study include practical difficulty of achieving lower border osteotomy through intra oral approach and the nature of dry mandible may be different from that of the alive mandible which may influence the outcome of the osteotomy. We recommend that this technique should be done with fresh cadaveric mandible through intra oral approach before attempting the technique in human orthognathic surgery.

Summary and Conclusion

SUMMARY AND CONCLUSION

The study was done to evaluate the influence of additional osteotomy at the inferior border of the mandible in addition to the classical Obwegeser and Dal-Pont technique of BSSRO. We did this study on 15 adult dry human cadaveric mandibles. We also included 15 fresh adult cadaveric mandible of the goat, sacrificed for the food as the control group because the physical properties of the dry human mandible would be different from that of fresh alive mandible which may influence the outcome of the study. In each mandible, Classical Obwegeser and Dal-Pont technique of BSSRO was done in left side and modified technique with additional inferior border osteotomy was done in right side. Lingual fracture pattern was assessed based on modified lingual split scale. The maximal force required to complete the split was calculated by the specially designed torque gauge. From this study we conclude that

- In the cadaveric dry mandible,80% of the mandibular split were Type I fracture pattern (along the mylohyoid sulcus) with the Obwegeser Dal Pont technique. In contrast with the modified technique with an additional osteotomy at the inferior border of the mandible 93% of the cases split by Type II fracture (along the lower border of the mandible).
- The mean average force required to complete the split with the Obwegeser Dal Pont technique was 12.6 $\pm$2.4 Nm. When using the modified technique with an additional osteotomy at the inferior border we recorded an average required torque of 8.7 $\pm$ 2.1 Nm. The new technique decreased the torque needed to split the jaw by 31 % when compared to the classical BSSO technique.

- The results of the adults human dry mandible highly correlates with that of the fresh goat mandible indicating that the obtained results are due to modification of the BSSRO osteotomy rather by the change in the physical properties of dry mandible.

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Annexures

ANNEXURE I

RAGAS DENTAL COLLEGE & HOSPITAL

(Unit of Ragas Educational Society)

Recognized by the Dental Council of India, New Delhi

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TO WHOM SO EVER IT MAY CONCERN

Date: 30.1.2019

Chennai.

From

The Institutional Review Board,

Ragas Dental College and Hospital,

Uthandi, Chennai- 600119.

The Dissertation topic titled **"EVALUATION OF LINGUAL FRACTURE PATTERN OF THE MANDIBLE AFTER BILATERAL SAGITTAL SPLIT OSTEOTOMY WITH AND WITHOUT INFERIOR BORDER OSTEOTOMY"** Submitted by **DR. ARUN VIGNESH.K.R** has been approved by the Institutional Review Board of Ragas Dental College & Hospital.

Dr.N.S.AZHAGARASAN, M.D.S

Member Secretary,

Institutional Ethical Board,

Ragas Dental College and Hospital,

Uthandi, Chennai - 600119

ANNEXURE II

URKUND

Urkund Analysis Result

Analysed Document: pilagrism check.docx (D47313633)
Submitted: 1/28/2019 7:45:00 AM
Submitted By: arunvigneshkr@gmail.com
Significance: 5 %

Sources included in the report:

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